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ABSTRACT

The effects of calculator use by college sophomores on measures of mathematical aptitudes and classroom examinations in the area of business statistics were studied. It was found that students using calculators during aptitude measures performed consistently better and sometimes significantly better than students who did not use calculators. During classroom exams, however, calculator usage was not associated with superior performance in most cases. Students who owned calculators were not consistently superior to non-owners on math aptitude measures. (Author/MP)

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The Effects of Student Calculator Use Upon Measures of Numerical Aptitude and Business Statistics

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Abstract

This study involves two efforts to examine the effects of calculator use by college sophomores on measures of mathematical aptitude and classroom material in the area of business statistics. It was found that students using calculators during aptitude measures performed consistently better and sometimes significantly better than students who did not use calculators. During classroom exams, however, calculator usage was not associated with superior performance in most cases. Students who owned calculators were not consistently superior to nonowners on math aptitude measures. Suggested reasons for the differences in effects are discussed and further research is proposed.

The Effects of Student Calculator Use Upon Measures of Numerical Aptitude and Business Statistics

In the past few years there has been growing concern over the introduction of pocket-calculators to the educational setting. Despite the rapid decrease in cost of these products over time, some students still do not own them, leading educators and others to consider philosophical issues related to the effects of calculator use in the classroom.

It has been suggested that (1) students able to purchase calculators may also be buying an academic advantage, (2) that such instruments may hinder the mastery of mathematical principles and/or (3) lead to a deterioration of numerical skills through increased dependence upon electronic calculation ("Tool or Crutch," 1973; Grosswirth, 1975; "Thank God He Doesn't Have To," 1975; Bishop, 1975; Gaster, 1975; Clark, 1975). Since it appears inevitable that calculators will become increasingly available to students at even the lowest levels of educational training (Goffa, 1976), one might expect to find considerable research into this area. In fact, only one published paper was located which described an empirical examination of calculator use in the classroom. Schafer, Bell, and Crown (1975) found that an experimental group of elementary age students using calculators on a mathematical aptitude test performed significantly better than a control group not using calculators.

In an effort to further explore this area, two studies were conducted. The purpose of the first study was to examine the effects of using a calculator upon mathematical aptitude scores. In the second study the intent was to investigate these same effects upon both aptitude scores and actual performance during classroom examinations requiring substantial numerical manipulation.

Given the lack of previous research on this topic, both studies must be considered exploratory in nature and therefore, no specific hypotheses were tested. It was felt, however, that these studies would allow the researchers to seek answers to some questions suggested by earlier writers:

1. Do students who use calculators perform significantly better on mathematical aptitude measures than students who do not?
2. Do students using calculators on classroom exams perform significantly better than students who do not?
3. Is calculator ownership related to mathematical aptitude?

Study 1

Method

College sophomores (n = 127) enrolled in a business course, were randomly assigned to one of four groups. It was found that the groups did not demonstrate significant differences with regard to the following variables: grade-point-average, ACT standard scores, having had previous calculator instruction, ownership of a calculator or, in having used a calculator elsewhere. The first group used calculators on a 40-item scale[1] of the Differential Aptitude Tests (DAT) which measures mathematical aptitude (The Psychological Corporation, 1972) and eight weeks later took the test a second time with calculators. The second group took the DAT at the same times as the first group but in neither instance were calculators allowed to be used. The third group used calculators on the DAT during the first administration but not on the second. Finally, the fourth group did not use calculators for the first DAT administration but did use them for the second. In summary the four groups were:

Group	Condition	N
1	With-With (W-W)	25
2	Without-Without (WO-WO)	29
3	With-Without (W-WO)	30
4	Without-With (WO-W)	43

To insure uniformity of calculator performance, all students were provided calculators and received instruction in their use, when necessary, prior to the study.

Results

Table 1 contains the means and standard deviations for each of the groups across the DAT measures for Time 1, Time 2, as well as a difference score between these two measures. In the first set of figures for Time 1 it was found that

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Insert Table 1 About Here

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the group means did not differ significantly ($F = 1.98$; $df = 3, 123$). It was also found that there were no significant differences across the group means on the second DAT measure ($F = .61$; $df = 3, 123$). It appeared, however, that the WO-W group may have made a more substantial mean gain over time than the other groups. Therefore, an analysis comparing the four groups against a difference score between the two DAT administrations was performed. The results of the analysis showed an overall effect which approached a conventional level of significance ($F = 2.25$; $df = 3, 123$; $p < .08$). Further, a post hoc comparison indicated that the WO-W group had made a significant mean gain over the W-WO group ($p < .05$).

Finally, an analysis of the effects of calculator ownership was initiated. To do this, attention was directed toward the second and fourth groups, WO-WO and WO-W, respectively. These groups were chosen because in neither case was the use of calculators allowed during the first test administration. Using declared calculator ownership as an independent grouping variable and DAT as the dependent variable, it was found that the group mean for these students owning calculators ($\overline{X}$ = 26.0; SD = 7.6)) was significantly (t = 2.19; p < .05) greater than the mean for the group which did not own calculators ($\overline{X}$ = 21.5; SD = 9.1).

Study 2

Method

Two classes of college sophomores enrolled in a business statistics course provided 266 subjects for the second study. Due to absenteeism and normal attrition, the total number of subjects used for analysis purposes varied across measures. The students were given forms S and T of the DAT numerical aptitude measure used in the first study. In addition, each class received three regular classroom examinations during the academic quarter. The DAT scores were pooled across classes and the classroom exam scores were subjected to a standard-score transformation prior to pooling them across classes for comparison purposes.

The administration of the measures mentioned above took place in each of the two classes on the same days and involved a total of five test sessions:

1. Students from the first class were administered DAT-S and were not allowed to use calculators. Students from the second class were given DAT-T and were also not allowed to use calculators.
2. The second test session took place on the next day and differed

from the first in two respects: The DAT forms were reversed for each class and all students were told in advance that calculators would be allowed during this session.

3. During the third test session the students in the first class took the first regular classroom examination without the use of calculators Students from the second class received their first exam and were allowed to use calculators.
4. The second classroom examination was given during the fourth test session. In this instance the first class was allowed to use calculators while the second class was not.
5. The fifth test session duplicated the third except that the measure taken was the third classroom examination.

Since the second study dealt with naturally occuring groups, no random assignment was possible. Further, since it was assumed that some students would elect not to use calculators when permission to do so was given, records of who used the instruments were retained and the results of analyses based on these data will be discussed later.

Results

Table 2 contains the means for groups who used or did not use calculators in each of the five test sessions. As can be seen in every instance in which calculators were used, the group using them received a higher average score. However, it should be noted that significant differences were found in only three of five sessions. The group using calculators did significantly better than their counterparts on the DAT-S ($p < .001$), DAT-T ($p < .01$), and the first classroom exam ($p < .05$).

Insert Table 2 About Here

Returning to a point raised earlier regarding the voluntary nature of the use of calculators, an analysis of the possible interaction between owning and using a calculator was performed. It was felt that differential performance related to subgroups who owned but did not use calculators or, conversely, used but did not own calculators, should be examined. In all instances of measurement, no significant interaction effects were found for these subgroups. This suggests that previous results comparing users and nonusers were probably not contaminated by persons who owned calculators but chose not to use them and vice versa.

An effort was made to investigate the effects of ownership upon performance across the DAT forms and classroom tests when the use of calculators was not allowed. In no instance was the performance of the owners of calculators superior to that of nonowners.

Discussion

The first question examined by these studies asks whether students using calculators have a significant advantage over those who do not use them on a measure of mathematical aptitude. The first study suggests that groups using calculators do somewhat better than those who do not but no significant differences between the groups were found. The second study found strong and significant mean differences favoring the groups using calculators. It was found in the first study, however, that the group which took the DAT without calculators and retook it with calculators showed a significant mean increase over the group which took the DAT the first time with calculators and the second

time without. This gain appears to not be a learning effect since it occurs predominately for only one group. Therefore, the answer to the first question seems to be a qualified "yes." Students using calculators do better and sometimes significantly better than students who do not use them. One caveat should be issued since it appears the groups in the first study showed considerably less mathematical aptitude than the groups in the second. According to records of GPA and ACT standard scores, differences in aptitude measures could be attributed to having below average subjects in the first study. Higher aptitude subjects may have been found in the second study due to self-selection when electing to take a statistics course. The latter explanation does not seem particularly persuasive since this class is required for all business students. Further, anecdotal information gathered from subjects in the first study indicated that students who were not allowed to use calculators believed their performance was hindered due to not being able to recall basic arithmetic rules. Assuming the first explanation has merit, it could be suggested that calculator use may be differentially related to one's level of mathematical aptitude. That is, there may be a threshold of mathematical ability which moderates the benefit gained from the use of a calculator.

Mathematical aptitude requires substantial reliance upon rote learning, leaving room for both computational and conceptual errors. Using a calculator may allow the student to avoid computational errors, thus reducing error unrelated to conceptual aptitude. This may explain why the WO-W group in the first study made greater gain than the W-WO group. In any event, restricting the use of a calculator could introduce "noise" into a system assessing mathematical aptitude.

The second question addresses the possibility that students using calculators during classroom exams may have an advantage over students not using calculators. It was found that the group which used calculators did significantly better on the first examination but that no significant group differences existed on subsequent exams. In discussions with the course instructors it was found that the content of the first exams included a substantial review of fundamental mathematical procedures necessary for continuing progress in the course. The remaining exams sampled only new material presented by the instructors. This content difference could explain the advantage gained by students using calculators since the first exam allowed more use of rote memory and, therefore, could allow the calculator user to avoid errors attributable to factors other than conceptual knowledge. Conversely, calculators did not seem to make a difference on later exams which required less computational operations and more conceptual processing. The researchers feel the answer to this second question is "probably not" since the one significant difference seems more related to exam content than to the use of a calculator.

A final question probes the possibility that persons who acquire calculators may differ in mathematical aptitude from those who do not. It was clearly shown in the first study that students who owned calculators did indeed achieve a significantly higher mean DAT score than students who did not own them. Contrary to this finding, students who owned calculators in the second study were not superior to individuals who did not own them with regard to DAT scores. Of course it is possible that such a discrepancy could be attributed to chance or to other factors such as a lack of random assignment in the second study. We would suggest, as an alternate explanation, that the ability factor raised earlier with regard to observed differences in demonstrated aptitude

between groups in the two studies applies here as well. One could argue that persons who tend to have levels of mathematical aptitude similar to these students in the first study may demonstrate a greater relationship between calculator ownership and aptitude than one would find for a group having the general level of aptitude found in the second study. At the lower levels it may seem relatively futile to purchase a calculating instrument when one's basic aptitude ceiling could limit its use; at higher levels, such a purchase may be made for purposes as varied as the scope of mathematics itself, thus masking any aptitude differences among persons in this group. In any case, no clear answer seem available for the third question since it appears that aptitude differences among persons will have to be examined on a more complex basis than mere calculator ownership, particularly in view of the remarkable and unabated proliferation of these devices over such a short period of time.

In conclusion, the results of these studies suggest that calculators at the educational level examined here are used as tools for expediting tedious repetitive arithmetic operations and for minimizing errors associated with such activity. It was also shown that these devices cannot be substituted for basic mathematical reasoning skill in classroom situations requiring more than rote numerical manipulation. Although these studies are exploratory and cannot be taken as conclusive evidence of the effects examined, they do provide an opportunity to replace opinion with data in this area. Much work remains to be done regarding other points raised for or against the introduction of calculators in the classroom. It will be necessary to employ longitudinal designs to test long-term effects of calculator use upon retention of basic numerical skills as well as to expand this investigation to include various academic levels and disciplines before educators can determine the overall impact of calculators in the educational system.

Footnotes

Requests for reprints should be sent to G. D. Kissler, Navy Personnel Research and Development Center (Code 302), San Diego, California 92152.

The opinions and assertions contained in this paper are those of the writers and are not to be construed as official or reflecting the views of the Navy Department.

[1]A random assignment of the alternate forms S and T of the DAT was made to group members during each administration.

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Table 1

Mean DAT Performance for Groups Differentiated by Calculator Use in Study 1

	Measures					
	Time 1		Time 2		Difference Score	
Group	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
W-W (With-With)	28.2	8.4	28.8	8.9	-.64	4.6
WO-WO (Without-Without)	24.4	8.0	25.9	8.2	-1.52	4.7
W-WO (With-Without)	27.3	6.6	27.1	8.8	.30	5.3
WO-W (Without-With)	24.1	8.7	27.1	7.1	-1.98	6.3

Note. Sample sizes for the W-W, WO-WO, W-WO, and WO-W groups are 25, 29, 30, and 43, respectively.

Table 2

Mean DAT and Classroom Exam Difference

for Classes 1 and 2 in Study 2

	Condition				
	Calculator[1]		No Calculator[2]		t-value
Measure	$\bar{X}$	SD	$\bar{X}$	SD	
DAT-S	35.63	3.1	33.71	4.5	3.00**
DAT-T	35.42	4.0	32.15	5.6	3.94***
Exam 1	.27	1.1	-.06	1.0	2.03*
Exam 2	.37	.8	.17	.9	1.22
Exam 3	.12	1.1	-.03	1.0	.85

[1] *n* ranged 31-47 for these groups.

[2] *n* ranged 152-197 for these groups.

*$p < .05$

**$p < .01$

***$p < .001$